

1 CLAIMS

2 1. An integrated circuit (IC) card comprising:

3 an input/output (I/O) interface; and

4 a smart card development interface, coupled to the I/O interface, to receive  
5 and identify one or more debug frames interlaced within a normal communication  
6 flow between the IC card and a host system.

7  
8 2. An IC card according to claim 1, further comprising:

9 a memory device having stored therein a plurality of executable  
10 instructions; and

11 a controller, coupled to the memory device and the smart card development  
12 interface, to execute at least a subset of the plurality of executable instruction to  
13 selectively implement one or more of a plurality of IC card applets.

14  
15 3. An IC card according to claim 2, wherein the memory device  
16 includes a plurality of executable instructions which, when executed, implement a  
17 debug application which selectively controls other applications executing on the  
18 IC card.

19  
20 4. An IC card according to claim 1, wherein the smart card development  
21 interface includes a debug filter to identify and remove the debug frames from the  
22 normal communication flow.  
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1           5.    An IC card according to claim 4, wherein the debug filter redirects  
2 the debug frames to a debug application on the IC card.

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4           6.    An IC card according to claim 1, further comprising a debug  
5 application, responsive to debug instructions embedded within received debug  
6 frames, the debug application providing a user with a host of application debug  
7 features enabled in response to the received debug instructions.

8  
9           7.    An IC card according to claim 6, wherein select debug instructions  
10 invoke one or more of the following debug features: read/write IC card memory,  
11 get/set breakpoints in an IC card applet, sequentially step an IC card application,  
12 run an IC card applet, and release an IC card applet frame.

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14           8.    An IC card according to claim 1, wherein the IC card communicates  
15 with a remote host system using a transport protocol comprising application data  
16 units (APDU) and debug protocol data units (DPDU).

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19           9.    An IC card according to claim 8, wherein the transport protocol is a  
20 standard smart card communication protocol, wherein the APDU and the DPDU  
21 adhere to the standard IC card communication protocol.

1           10. An IC card according to claim 8, wherein the smart card  
2 development interface further comprises a debug filter which identifies DPDU  
3 within the normal communication flow to redirect the DPDU to a debug  
4 application on the IC card.

5  
6           11. An IC card according to claim 10, wherein the debug filter identifies  
7 DPDU within the normal communication flow by detecting an invalid source  
8 and/or destination address identifier within the debug frame.

9  
10          12. An IC card according to claim 1, wherein the IC card communicates  
11 with a remote host system using a transport protocol comprising application data  
12 units (APDU) including normal application frames and debug frames.

13  
14          13. A storage medium having stored thereon a plurality of executable  
15 instructions which, when executed, implement the smart card development  
16 interface of claim 1.

17  
18          14. A method of debugging a smart card application, the method  
19 comprising:

20           receiving one or more debug frames interlaced with application frames  
21 comprising a normal communication flow between a smart card and a host system;

22           identifying the one or more debug frames;

23           routing the received debug frames to a debug application executing on the  
24 smart card, while promoting the application frames to an application executing on  
25 the smart card, subject to conditions imposed by the debug frames.

1  
2 15. A method according to claim 14, wherein the step of identifying the  
3 one or more debug frames comprises:

4 reading a source and/or destination address of frames comprising the  
5 normal communication flow; and

6 detecting invalid source and/or destination addresses in select frames  
7 denoting debug frames.

8  
9 16. A method according to claim 14, further comprising:  
10 implementing one or more debug features on the smart card according to  
11 debug instructions embedded within the received debug frames.

12  
13 17. A method according to claim 16, wherein the debug features include  
14 one or more of read/write smart card memory, get/set breakpoints in a smart card  
15 application, sequentially step a smart card application, run a smart card  
16 application, and release a smart card application frame.

17  
18 18. A method according to claim 14, further comprising:  
19 generating a response debug frame to a received debug frame;  
20 interlacing the response debug frame with response application frames; and  
21 sending the response debug frame and response application frames to a host  
22 system.

1           19.    A storage medium having stored thereon a plurality of instructions  
2 which, when executed, implement the method of claim 14.

3  
4           20.    A computer system comprising:  
5           an input/output (I/O) interface; and  
6           a client development interface, coupled to the I/O interface, to receive and  
7 identify debug frames interlaced within the normal communication flow between  
8 the computer system and a removably coupled smart card.

9  
10          21.    A computer system according to claim 20, further comprising:  
11          a memory device having stored therein a plurality of instructions; and  
12          a processor, coupled to the memory device and the client development  
13 interface, to execute at least a subset of the plurality of instructions to implement  
14 one or more applications including a smart card development application having a  
15 debug environment to send and receive debug frames to the coupled IC card  
16 interlaced within the normal communication flow between the computer system  
17 and the IC card.

18  
19          22.    A computer system according to claim 14, wherein the memory  
20 device includes a plurality of executable instructions which, when executed,  
21 implement a debug application on the computer system to communicate with and  
22 control smart card resources.

1 23. A computer system according to claim 20, wherein the client  
2 development interface includes a debug filter to identify and remove the debug  
3 frames from the normal communication flow between the computer system and  
4 the smart card.

5  
6 24. A computer system according to claim 23, wherein the debug filter  
7 redirects debug frames received from the smart card to a debug application  
8 executing on the computer system.

9  
10 25. A computer system according to claim 20, further comprising a  
11 debug application, to write and read debug frames to and from the smart card,  
12 facilitating a number of application debugging features.

13  
14 26. A computer system according to claim 25, wherein the debug  
15 frames written by the debug application invoke one or more of the following  
16 debug features: read/write smart card memory, get/set breakpoints in a smart card  
17 application, sequentially step a smart card application, run a smart card  
18 application, and release a smart card application frame.

19  
20 27. A computer system according to claim 20, wherein the computer  
21 system communicates with the smart card using a transport protocol comprising  
22 application data units (APDU) and debug protocol data units (DPDU).  
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1        28. A computer system according to claim 27, wherein the client  
2 development interface further comprises a debug filter which identifies DPDU  
3 within the normal communication flow to redirect the DPDU to a debug  
4 application executing on the computer system.

5  
6        29. A computer system according to claim 29, wherein the debug filter  
7 identifies DPDU within the normal communication flow by detecting an invalid  
8 source and/or destination address identifier within the debug frame.

9  
10       30. A storage medium having stored thereon a plurality of executable  
11 instructions which, when executed, implement the client development interface of  
12 claim 20.

13  
14       31. A computer-implemented method for debugging a smart card  
15 application, the method comprising:

16        generating one or more debug frames containing debug instructions;

17        interlacing the generated debug frames with one or more application frames  
18 generated according to an application executing on the computer; and

19        sending the application frames with the interlaced debug frames to a  
20 removably coupled smart card, wherein the debug frames invoke one or more  
21 debug features of the smart card.

1           32. A computer-implemented method according to claim 31, wherein  
2 the application frames are generated by an application executing within an  
3 application development environment, while the debug frames are generated in  
4 response to user interaction with the smart card application development  
5 environment.

6  
7           33. A computer-implemented method according to claim 31, wherein  
8 generating one or more debug frames comprises populating a source and/or  
9 destination field of the debug frame with an invalid source and/or destination  
10 address.

11  
12           34. A computer-implemented method according to claim 31, further  
13 comprising:

14           receiving a normal communication flow from the smart card including  
15 debug frames interlaced with application frames, wherein the debug frames  
16 received from the smart card are received in response to debug frames issued by  
17 the computer.

18  
19           35. A computer-implemented method according to claim 34, wherein  
20 the application frames are promoted to an associated application executing within  
21 an application development tool executing on the computer, while the debug  
22 frames are promoted to an application debug environment of the application  
23 development tool executing on the computer.  
24  
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1        36.    A communication protocol, employed between a host system and a  
2 smart card, the protocol comprising:

3        a plurality of application frames comprising a normal communication flow  
4 between a host application and a smart card application; and

5        one or more debug frames, interlaced with the application frames within the  
6 normal communication flow, to enable a debug application executing on the host  
7 system to selectively access and control smart card resources.

8  
9        37.    A communication protocol according to claim 36, wherein the  
10 debug application and the host application are executing on separate host systems,  
11 each communicatively coupled to the smart card.

12  
13        38.    A communication protocol according to claim 36, wherein the one  
14 or more debug frames include debug instruction to implement one or more of the  
15 following debug features: read/write smart card memory, get/set breakpoints in a  
16 smart card application, sequentially step a smart card application, run a smart card  
17 application, and release a smart card application frame.

18  
19        39.    A communication protocol according to claim 36, wherein the  
20 debug frame is distinguished from an application frame by incorporating an  
21 invalid source address.

1        40. A communication protocol according to claim 36, wherein the  
2 debug frame is distinguished from an application frame by incorporating an  
3 invalid destination address.

4  
5        41. An application development system comprising:  
6 a computer system to execute an application within an application  
7 development tool; and  
8 a smart card incorporating a smart card development interface, coupled to  
9 the computer system, to receive and identify debug frames interlaced with  
10 application frames within a normal communication flow between the application  
11 executing on the computer system and the smart card, wherein the smart card  
12 development interface promotes the application frames to an application layer of  
13 the smart card, and invokes debug features of the smart card in response to debug  
14 instructions embedded within the received debug frames.

15  
16        42. An application development system according to claim 41, wherein  
17 the computer system further comprises:

18 a client development interface, to interlace debug frames generated by the  
19 application development tool with application frames generated by the application  
20 executing within the application development tool.

21  
22        43. An application development system according to claim 42, wherein  
23 the application development tool generates debug frames in response to user  
24 interaction with the application development tool.  
25

1           44.    An application development system according to claim 43, wherein  
2 the application development tool populates a source and/or destination field of the  
3 debug frame with an invalid source and/or destination address.

4  
5           45.    An application development system according to claim 43, wherein  
6 the debug frames invoke and control one or more smart card resources facilitating  
7 debugging of the application executing within the application development tool of  
8 the computer system.

9  
10          46.    An application development system according to claim 42, wherein  
11 the client development interface includes a debug filter to identify and route debug  
12 frames received from the smart card.

13  
14          47.    An application development system according to claim 41, wherein  
15 the smart card development interface comprises a debug filter to identify debug  
16 frames within the received normal communication flow.

17  
18          48.    An application development system according to claim 47, wherein  
19 the debug filter identifies debug frames by an invalid source and/or destination  
20 address embedded within a source and/or destination field of the debug frame.

21  
22          49.    An application development system according to claim 41, further  
23 comprising:

24               a communication protocol, employed by the computer system and the smart  
25 card to communicate therebetween, the communication protocol comprising,

~~one or more debug frames, interlaced with the application frames within the normal communication flow, to enable a debug application executing on the host system to selectively access and control smart card resources.~~

~~one or more debug frames, interlaced with the application frames within the normal communication flow, to enable a debug application executing on the host system to selectively access and control smart card resources.~~

within the normal communication flow, to enable a debug application  
executing on the host system to selectively access and control smart card  
resources.